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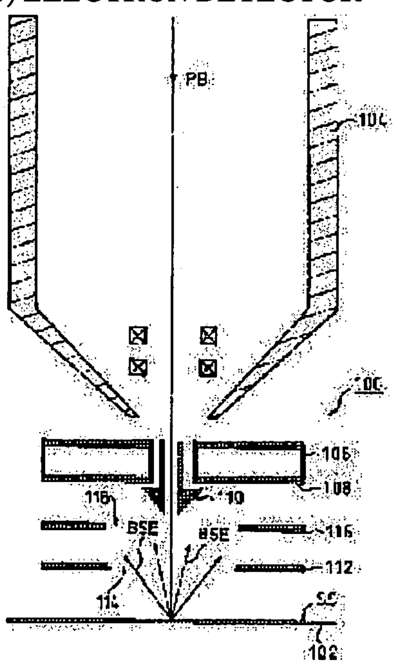
(54) ELECTRON DETECTOR



(57)Abstract:
PURPOSE: To provide an electron detector whose collection and detection of back scattered electrons is enhanced by equipping it with an energy filter for blocking secondary electrons emitted from a test piece.
CONSTITUTION: An electron detector 100 is equipped with an energy filter for blocking secondary electrons emitted from a test piece 102 so that only backscattered electrons reach an electron multiplier. The energy filter can accomplish its objective most effectively by providing a generally ring electrode 112 which is biased with a negative electric potential with respect to the test piece 102 and setting the potential difference between a center of its opening 114 and the test piece 102 to be -50 V or less.

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CLAIMS

[Claim(s)]
[Claim 1] It is an electronic detector for detecting the back scattering electron emitted from the test piece. (a) When it has the plane of incidence for collecting back scattering electrons and a back scattering electron collides with the non-active region of this plane of incidence, the secondary electron of the 1st type is emitted. The electron multiplier which has the orbit into which said 1st type of secondary electron separates from said plane of incidence, (b) Preventing that the secondary electron of the low energy which has been arranged between said electron multipliers and said test pieces, and was emitted with said test piece reaches to said electron multiplier The 1st electrode by which bias is carried out to the potential of minus to said test piece so that the 1st electric field which enable the back scattering electron of the high energy emitted from the test piece towards said electron multiplier to pass may be generated, (c) It is arranged between said electron multiplier and said 1st electrode, and bias is carried out to the potential of minus to said plane of incidence. And turn the orbit of said 1st type of secondary electron to said plane of incidence, and it is reversed substantially. The electronic detector characterized by providing the 2nd electrode currently isolated from said plane of incidence by distance which generates the 2nd electric field so that said plane of incidence can collect said 1st type of secondary electrons.
[Claim 2] Said 1st electrode is an electronic detector [equipped with opening which passes the back scattering electron of whenever / predetermined / for it being annular and making said electron multiplier reach / solid angle] according to claim 1.
[Claim 3] Said 2nd electrode is an electronic detector [equipped with opening which passes the back scattering electron of whenever / predetermined / for it being annular and making said electron multiplier reach / solid angle] according to claim 1.
[Claim 4] It is the electronic detector according to claim 1 which bias of said single electrode is carried out to the potential of minus to said plane of incidence and test piece by transposing said 1st electrode and said 2nd electrode to the single electrode arranged between said electron multipliers and test pieces so that said 1st and 2nd electric fields may be generated, and is isolated from said plane of incidence.
[Claim 5] Said electrode is an electronic detector [equipped with opening which passes the back scattering electron of whenever / predetermined / for it being annular and making said electron multiplier reach / solid angle] according to claim 4.
[Claim 6] The electronic detector according to claim 1 which possesses further the 3rd

electrode in potential which is arranged between said 2nd electrode and test pieces, and functions as a Faraday cage for the electronic detector concerned.
[Claim 7] The beam shielded tube for the path of the particle beam which faces to said test piece is provided further. This beam shielded tube When a back scattering electron collides to this beam shielded tube, the secondary electron of the 2nd type is emitted, and said 2nd type of secondary electron has the orbit which separates from said beam shielded tube. Said 2nd electric field The electronic detector according to claim 1 generated so that said plane of incidence may also collect said 2nd type of secondary electrons by reversing substantially the orbit of said 2nd type which goes to said plane of incidence of secondary electron.
[Claim 8] Said beam shielded tube is an electronic detector according to claim 7 which has a slanting end face.
[Claim 9] Said beam shielded tube is an electronic detector according to claim 7 currently manufactured from the ingredient which has a larger secondary-electron-emission multiplier than 1.
[Claim 10] Particle beam equipment which includes the electronic detector indicated by claim 1 for detecting the back scattering electron emitted from the test piece.

[Translation done.]
DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Industrial Application] This invention relates to an electronic detector and the electronic multiplication detector which performs collection detection of a back scattering electron especially.
[0002]
[Description of the Prior Art] Particle beam equipments, such as a scanning electron microscope, electron beam RISOGURAFU equipment, and ion beam RISOGURAFU equipment, are used in the wide range field. In principle, particle beam equipment scans the front face of a test piece by the accelerated particle beam. An electron is emitted when a particle beam collides to the front face of a test piece. The electron emitted with the energy which exceeds 50eV according to the nomenclature accepted today is called a back scattering electron (BSE), and the electron emitted with energy 50eV or less is called a secondary electron (SE). In the case of about 1000eV particle beam, typically, the emitted electron is divided equally between a back scattering electron and a secondary electron.
[0003] Although the back scattering electron includes the information contrasted with an ingredient, it is known that the secondary electron includes the information about the shape of surface type. There is inspection of the VLSI equipment with which that the collection detectivity of a back scattering electron is large observes the trench of a semiconductor material, the pars basilaris ossis occipitalis of a contact hole, etc. as a special application of the particle beam equipment demanded. Since the early electronic detector which detects a back scattering electron is indicated by L.Reimer work, "Image Formation in Low Voltage Scanning Electron Microscopy", SPIE Optical EngineeringPress, Bellingham, Washington, USA, 1993 annual publications, and 31-41 pages, explanation here is omitted. Generally, the electronic detector contains the conversion plate which absorbs a back scattering electron and emits a secondary electron, and these secondary electrons are detected by the scintillator detector of an Everhart-Thornley mold. Since a scintillator is typically held with these electronic detectors at the potential which is 5-10kV, in order to prevent that a beam separates from an orbit greatly, it was required that a detector should have been put on the location distant from the particle beam, therefore the collection detectivity (Backscattered Acceptance)

of a back scattering electron was restricted. Here, the collection detectivity (Backscattered Acceptance) of a back scattering electron shows a thing the thing of which reaches an electronic detector and is captured the total detection efficiency of the back scattering electron which reaches an electronic detector and is captured (detection), i.e., the inside of all back scattering electrons, (detection).

[0004] The electronic detector manufactured as a micro-channel-plate electron multiplier or a solid state electron multiplier is used for the latest electronic detector which detects the back scattering electron from a test piece. The equipment containing such an electronic detector is Artificer's Lee United States patent number No. 4,933,552, and "Inspection System Utilizing Retarding Field BackScattered Electron collection". Since it is indicated, explanation here is omitted. Here, the particle beam is turned to the test piece through one bias plate and an annular detector in the shape of a column, and the test piece is held to these bias plate and the detector at minus bias. In order that minus bias may suppress to the minimum that a test piece is charged, an incident beam is chosen so that it may collide with a test piece with the so-called crossover energy. With this crossover energy, since the number of the electrons included in the piece of an incident beam blank test and the number of the electrons emitted from a test piece become equal, charge of a test piece becomes min. Minus bias is effective also in order to divide into space between the back scattering electrons and secondary electrons which have a big longitudinal direction velocity compornent at a detector flat surface.

[0005] This configuration has the two main faults. Although the small back scattering electron of a longitudinal direction velocity compornent becomes most part of the total back scattering electron burst size when a particle beam carries out [1st] incidence perpendicularly to a test piece, in the above-mentioned detector, the collection detectivity of the small back scattering electron of a longitudinal direction velocity compornent is low. The peak value of distribution of the longitudinal direction velocity compornent of the back scattering electron emitted from the test piece in this case actually becomes the location of longitudinal direction rate zero. It is difficult to maintain the test piece to the minus potential of homogeneity, scanning the test piece which actually has high insulation in the 2nd by the charged particle beam. Other concrete examples of utilizing a micro-channel-plate electron multiplier or a solid state electron multiplier Michael T.Postek & William J.Keery collaboration, "Low-profile high efficiency microchannel plate detector system for scanning electron microscopy application", Review of Scientific Instruments, vol.61, and no.6 months, the June, 1990 issue, Since it is explained to 1648 - 1657 pages, explanation here is omitted. Here, in order to prevent separating from an orbit, as a particle beam results in a test piece, it passes along the inside of a beam shielded tube. Therefore, the focus of a beam becomes just under a beam shielded tube. When used as a back scattering electron detector, the front face of an electron multiplier is held to the usually grounded test piece at the potential not more than -50V.

[0006] This configuration also has the low collection detectivity of a back scattering electron because of many reasons. It is only that the 1st electron multiplier detects the back scattering electron of energy higher than the potential of itself. Many back scattering electrons called [2nd] below the back scattering electron of Type A are not detected since their collide with the field between the active channels of an electron multiplier. Typically, the plane of incidence of an electron multiplier is undetectable there, even if it consists of an active field (active areas) which can capture and detect an electron, and a non-active region (inactive areas) which cannot detect an electron there even if an electron carries out incidence and a back scattering electron collides with this non-active region. Furthermore, a smaller number of back scattering electrons called below the back scattering electron of Type B are also not detected in order that their may collide with a beam shielded tube.

[0007] Since they occupy the remarkable percentage of the total amount of back scattering electrons, these back scattering electrons that are not detected worsen considerably the quality

of the image obtained by the electronic detector. J. A.Panitz & A.Foesch collaboration, "Areal detection efficiency As explained to issue in of channel electron multiplier arrays", Review of Scientific Instruments, vol.47, and no.1 month and January, 1976 Area-detection efficiency of a micro-channel-plate electron multiplier (with the area of the whole plane of incidence of Areal Detection Efficiency and a micro-channel-plate electron multiplier) Generally the ratio of an area effective (active) when detecting an electron is about 60% slightly. Therefore, the back scattering electron of Type A forms about 40% of the back scattering electron. Although the back scattering electrons of Type B are usually more few, they has often occupied [the back scattering electron of Type B] most back scattering electrons in application to which the electron emitted from a test piece progresses especially in accordance with a particle beam shaft.

[0008] Therefore, there is no above-mentioned fault and the large electronic detector of back scattering electron collection detectivity is needed. The main purposes of this invention are to offer the electronic detector with the large collection detectivity (total detection efficiency) of a back scattering electron which in other words can collect as many back scattering electrons as possible, and can detect them.

[0009]

[Means for Solving the Problem and its Function] It is an electronic detector for detecting the back scattering electron emitted from the test piece according to the basic configuration of this invention. (a) When it has the plane of incidence for collecting back scattering electrons and a back scattering electron collides with the non-active region of this plane of incidence, the secondary electron of the 1st type is emitted. The electron multiplier which has the orbit into which said 1st type of secondary electron separates from said plane of incidence, (b) Preventing that the secondary electron of the low energy which has been arranged between said electron multipliers and said test pieces, and was emitted with said test piece reaches to said electron multiplier The 1st electrode by which bias is carried out to the potential of minus to said test piece so that the 1st electric field which enable the back scattering electron of the high energy emitted from the test piece towards said electron multiplier to pass may be generated, (c) It is arranged between said electron multiplier and said 1st electrode, and bias is carried out to the potential of minus to said plane of incidence. And turn the orbit of said 1st type of secondary electron to said plane of incidence, and it is reversed substantially. The electronic detector possessing the 2nd electrode currently isolated from said plane of incidence by distance which generates the 2nd electric field so that said plane of incidence can collect said 1st type of secondary electrons is offered.

[0010] The 2nd above-mentioned electric field are reversed so that the orbit may go to the plane of incidence of an electron multiplier, and the secondary electron of the 1st type emitted when the back scattering electron emitted from the test piece collided with the plane of incidence of an electron multiplier by the above configuration is detected by the electron multiplier after all. Therefore, the back scattering electron to which collided with the non-active region of the plane of incidence of an electron multiplier, and the secondary electron of the 1st type was made to emit can also be set as the object of detection of an electron multiplier, and the collection capacity (total detection efficiency) of a back scattering electron is made to increase.

[0011] According to the 1st gestalt of this invention, by transposing said 1st electrode and said 2nd electrode to the single electrode arranged between said electron multipliers and test pieces, bias is carried out to the potential of minus to said plane of incidence and test piece so that said single electrode may generate said 1st and 2nd electric fields, and it is isolated from said plane of incidence. According to the 2nd gestalt of this invention, the 1st electrode is annular and is equipped with opening which passes the back scattering electron of whenever [predetermined / for making an electron multiplier reach / solid angle].

[0012] According to the 3rd gestalt of this invention, the 2nd electrode is annular and is

equipped with opening which passes the back scattering electron of whenever [predetermined / for making an electron multiplier reach / solid angle]. According to the 4th gestalt of this invention, an electronic detector is arranged between the 2nd electrode and a test piece, and possesses further the 3rd electrode in potential which functions as a Faraday cage for the electronic detector concerned. It prevents that the above-mentioned electric field have inconvenient effect on a test piece by this.

[0013] According to the 5th gestalt of this invention, an electronic detector The beam shielded tube for the path of the particle beam which faces to said test piece is provided further. This beam shielded tube When a back scattering electron collides to this beam shielded tube, the secondary electron of the 2nd type is emitted, and said 2nd type of secondary electron has the orbit which separates from said beam shielded tube. Said 2nd electric field By reversing substantially the orbit of said 2nd type which goes to said plane of incidence of secondary electron, it is generated so that said plane of incidence may also collect said 2nd type of secondary electrons.

[0014] The 2nd above-mentioned electric field are reversed so that the orbit may go to the plane of incidence of an electron multiplier, and the secondary electron of the 2nd type emitted when the back scattering electron emitted from the test piece collided with a beam shielded tube by this is also detected by the electron multiplier after all. Therefore, the back scattering electron to which collided with the beam shielded tube and the secondary electron of the 2nd type was made to emit can also be set as the object of detection of an electron multiplier, and the collection capacity (total detection efficiency) of a back scattering electron is made to increase further.

[0015] According to the 6th gestalt of this invention, a beam shielded tube has a slanting end face. Thereby, it is a secondary electron. Lambertain Since the peak of angular distribution is leaned towards the direction of an electron multiplier, the collection capacity (total detection efficiency) of a back scattering electron is made to increase further. According to the 7th gestalt of this invention, the beam shielded tube is manufactured from the ingredient which has a larger secondary-electron-emission multiplier than 1.

[0016] According to the 8th gestalt of this invention, particle beam equipment includes the electronic detector by the basic configuration of above-mentioned this invention for detecting the back scattering electron emitted from the test piece.

[0017]

[Example] Drawing 1 is a schematic diagram of the 1st example of the large electronic detector of the collection detectivity (total detection efficiency) of a back scattering electron arranged to the exterior of the optical column (optical column) of particle beam equipment. In drawing 1 , 100 is the electronic detector of this invention and detects the back scattering electron emitted from a test piece 102 by carrying out incidence of the particle beam PB emitted from particle beam equipment to a test piece 102. In the configuration illustrated, although the electronic detector 100 is arranged to the exterior of particle beam equipment, with the configuration illustrated by drawing 8 mentioned later, the electronic detector 100 is arranged inside the optical column (optical column) 104 of particle beam equipment. Theoretically, particle beam equipment 104 gives the particle beam PB which has typically larger energy than 200eV, in order to observe the top front face SS of a test piece 102. A particle beam PB collides with the front face SS of a test piece 102, and an electron is made to be emitted from there. The emitted electron has the energy of the range of the kinetic energy of a particle beam PB from 0. Although the electron emitted with the energy exceeding 50eV is called a back scattering electron (BSE) according to the nomenclature accepted today, the electron emitted with energy 50eV or less is called a secondary electron (SE).

[0018] Generally the electronic detector 100 possesses the beam shielded tube 110 equipped with the plane of incidence 108 for capturing a back scattering electron which passed along the annular electron multiplier 106 and the electron multiplier 106, and has been further

extended from the anterior part of plane of incidence 108 to the front. The beam shielded tube 110 is formed in order to prevent the orbit of a particle beam PB shifting while going to the piece 102 of particle beam equipment 104 blank test. An electron multiplier 106 can be manufactured as a micro channel electron multiplier, a solid state electron multiplier, etc.
[0019] If only the electron with which the electronic detector 100 exceeds a certain threshold is put in another way, the description of this invention is to provide the energy filter for preventing the secondary electron emitted from the test piece 102 so that only a back scattering electron may reach an electron multiplier 106. bias of this energy filter was carried out to the potential of minus to the test piece 102 -- if the annular electrode 112 is generally formed and it is made for the core of that opening 114 and the potential difference between test pieces 102 to become less than [-50V], it will be attained most effectively.
[0020] Furthermore, according to the purpose of the electronic detector 100 of this invention, the electronic detector 100 detects not only the back scattering electron directly captured in the plane of incidence 108 of an electron multiplier 106 by those collisions but the back scattering electron which is not captured directly. These back scattering electrons are classified into two as shown below. That is, it is the back scattering electron which collides with the non-active region (inactive areas) of the plane of incidence 108 of an electron multiplier 106, and the back scattering electron of Type A is called [1st]. And to the 2nd, it is the back scattering electron which collides with the beam shielded tube 110, and the back scattering electron of Type B is called.
[0021] In this way, the electronic detector 100 detects the secondary electron of low energy shown by SE-B emitted when the secondary electron of the low energy shown by SE-A actually emitted when the back scattering electron of Type A collides with plane of incidence 108, and the back scattering electron of Type B collide with the beam shielded tube 110. Since both these secondary electron SE-A and SE-B have the orbit which separates from plane of incidence 108, capture of these secondary electron SE-A in plane of incidence 108 and SE-B needs to give the electric field which reverse an orbit substantially so that those orbits may go to plane of incidence 108, as shown in drawing 2 and drawing 3 , respectively.
[0022] It is most effectively given with the annular electrode 116, and generally, since [which generates this electric field] such electric field are equipped with opening 118 and arranged between plane of incidence 108 and an electrode 112, the following potentials are given. It is required [1st] that bias of the plane of incidence 108 of an electron multiplier 106 should be carried out to the potential of plus to an electrode 116. Suitably, bias of the plane of incidence 108 of an electron multiplier 106 is carried out [2nd] to the potential of plus to the beam shielded tube 110. Furthermore, according to the occasional specific application example, bias of the beam shielded tube 110 is suitably carried out to the same potential or the potential of plus substantially to an electrode 116 the 3rd. The plane of incidence 108 of an electron multiplier 106 should be noticed also about the potential of plus to the test piece 102 the same potential or that bias can be carried out to a test piece 102 also at the potential of minus as substantially as a test piece 102.
[0023] Drawing 4 is drawing showing the typical potential distribution in the interior of the electronic detector of drawing 1 according to the idea of this invention. In drawing 4 , it is illustrating by one side about the typical electrical potential difference as shows below inhibition of the secondary electron emitted from the test piece 102, and the electric field which spread on the other hand inside the electronic detector 100 which reverses the orbit of secondary electron SE-A and SE-B for explanation. That is, an electrode 112 is the electrical potential difference of -110V, the plane of incidence 108 of an electron multiplier 106 is the electrical potential difference of +150V, and the front face SS of a test piece 102, the beam shielded tube 110, and an electrode 116 are the electrical potential differences of 0V. As mentioned above, in order to attain the electric field demanded, it is considered to be understood easily for this contractor that an electrical potential difference and an electrical-

potential-difference difference can be taken broadly.
[0024] The further description of this invention is by choosing so that only the back scattering electron of whenever [solid angle / to which it was beforehand set in the diameter of those openings 114 or 118 any of an electrode 112 or an electrode 116 they are] may pass openings 114 or 118 and can reach an electron multiplier 106 to be able to use it as a spatial filter. In addition, the orbit of the back scattering electron which generally has hundreds of eV energy is hardly bent, when they pass along electrodes 112 and 116.
[0025] The further description of this invention is for the probability for the back scattering electron of Type B to be detectable to increase, sharply by the suitable design of the beam shielded tube 110. Especially emission of the secondary electron by the back scattering electron of Type B colliding on the beam shielded tube 110 makes the end of the beam shielded tube 110 slanting (bevel), and it is increased by leaning so that the peak of the Lambertain angular distribution of a secondary electron may be suitable in the direction of an electron multiplier 106. Furthermore, the beam shielded tube 110 can be manufactured from the ingredient which has a larger secondary-electron-emission multiplier than 1. In relation to the photoelectron multiplication machine component, it inquires broadly, and such an ingredient is the volume on L.Martin, "Advances in Electronics", and vol. Since it is explained to 65-130 pages of Academic Press Inc., NEW York, and NY 1948 annual publication, Kenneth G.McKay work, and "Secondary Electron Emission" at the detail, explanation here is omitted.
[0026] Next, drawing 5 and drawing 6 are referred to. Drawing 5 is the schematic diagram of the 2nd example. At drawing 5 , 120 shows the 2nd example of the electronic detector of this invention. Since the electronic detector 120 of drawing 5 is similar with the electronic detector 100 of the 1st above-mentioned example in structure and actuation, the same number is appended to the same component. The primary difference of the electronic detector 120 of the 2nd example and the electronic detector 100 of the 1st example has the electronic detector 120 in replacing with electrodes 112 and 116 and using the single electrode 122.
[0027] On the other hand, it is illustrated about the typical electrical potential difference which prevents the secondary electron emitted from the test piece 102 on the other hand and which the electric field which spread substantial reversal of the orbit of secondary electron SE-A and SE-B inside the electronic detector 120 show below. That is, an electrode 122 is the electrical potential difference of -150V, the plane of incidence 108 of an electron multiplier 106 is the electrical potential difference of +150V, and the front face SS and the beam shielded tube 110 of a test piece 102 are the electrical potential difference of 0V. As mentioned above, in order to attain the electric field demanded, it is considered to be understood easily for this contractor that an electrical potential difference and an electrical-potential-difference difference can be taken broadly.
[0028] In a certain application, especially in order to prevent that a test piece is influenced by the electric field inside the electronic detector 100, cautions are required. The above electric fields may have fault effect on the function of other detectors of a test piece 102 or particle beam equipment. Electric shielding of a test piece 102 is held at the typically almost same potential as a test piece 102, and by giving the electrode 124 which acts as a Faraday cage and confines electric field in the electronic detector 100 interior, it can be realized so that it may be illustrated by drawing 7 .
[0029] As mentioned above, drawing 8 shows the 2nd configuration by which the electronic detector 100 is arranged inside the optical column (opticalcolumn) of particle beam equipment 102. In this case, the potential of each component of the electronic detector 100 is related to the common potential of an optical column (optical column). The primary difference with a configuration of being shown in this configuration and drawing 1 has electromagnetic lens EL in their acting [by] like a back scattering electron, when the kinetic energy of these secondary electrons is accelerated towards the electronic detector 100 by

increasing thousands of eV and these secondary electrons reach the electronic detector 100 in the secondary electron emitted from the test piece 102. Therefore, the configuration of this electronic detector 100 gives the high collection detectivity of a back scattering electron and secondary electron both.

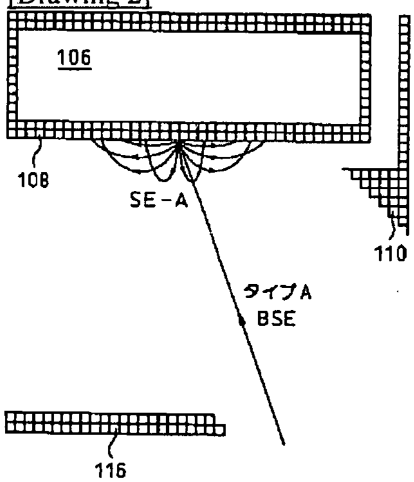
[0030]

[Effect of the Invention] The electronic detector with the large collection detectivity (total detection efficiency) of a back scattering electron which in other words can collect as many back scattering electrons as possible, and can detect them can be offered.

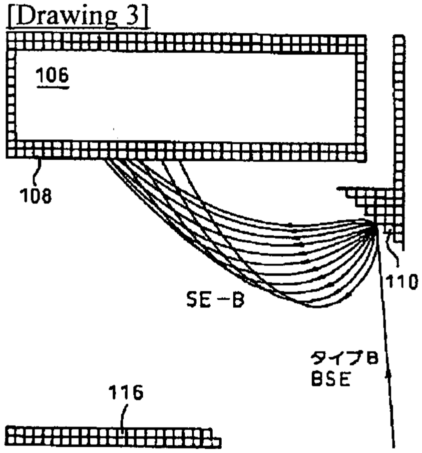
[Translation done.]

DRAWINGS

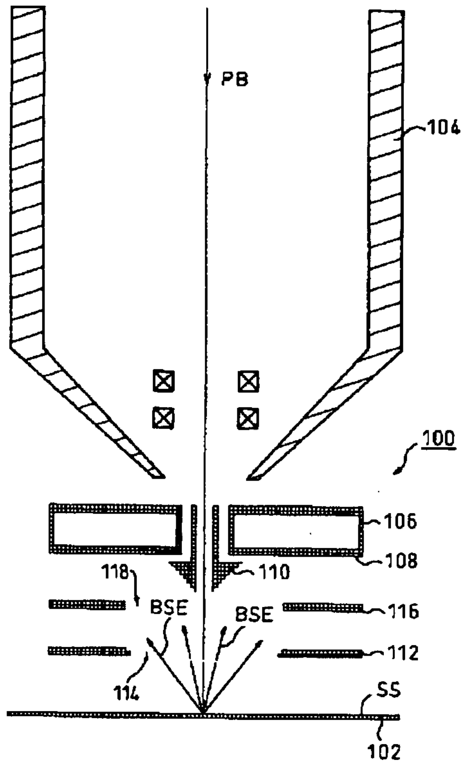
[Drawing 2]



[Drawing 3]



[Drawing 1]



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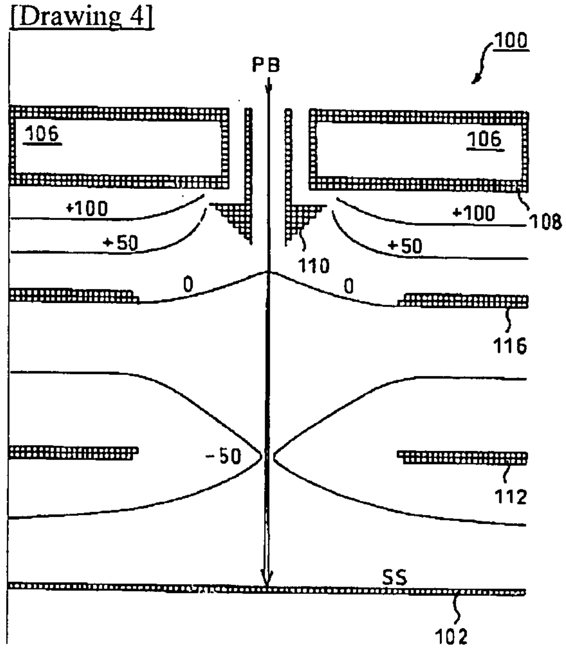
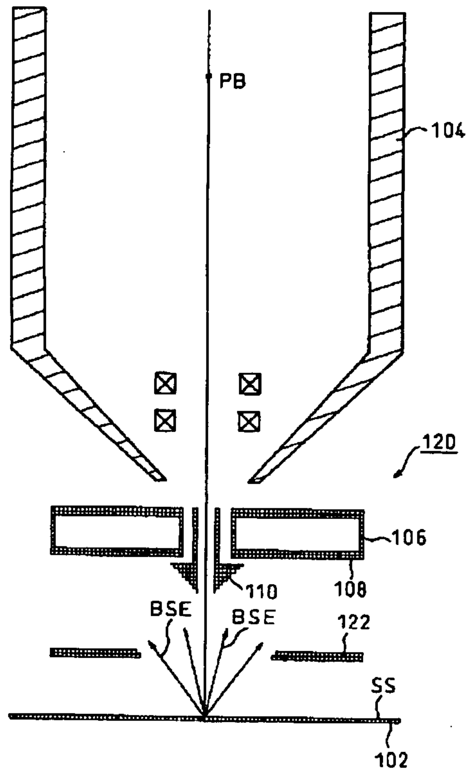
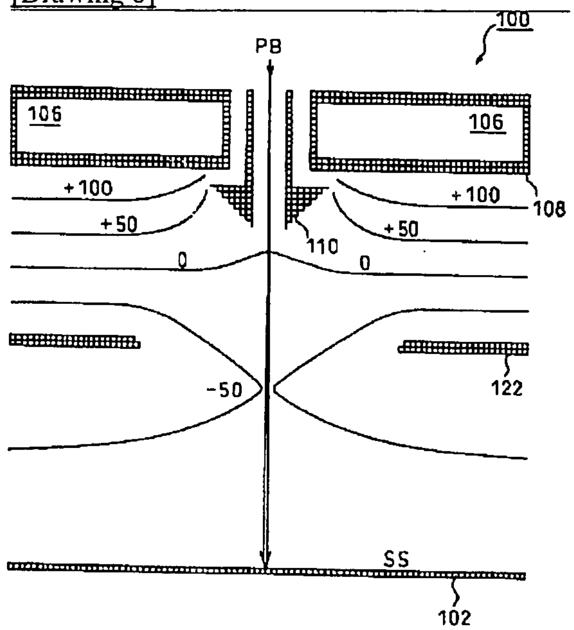


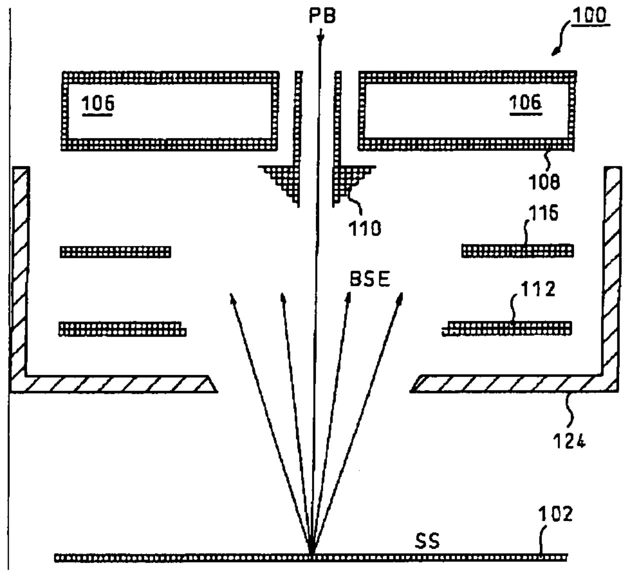
[Drawing 5]



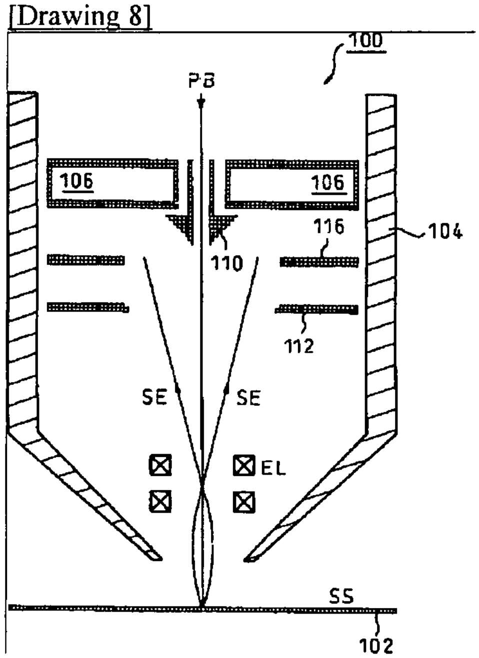
[Drawing 6]



[Drawing 7]



[Drawing 8]



[Translation done.]